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PRODUCTION OF EXPLOSIVES IN THE UNITED STATES

DURING THE CALENDAR YEAR 1919

WITH NOTES ON COAL-MINE ACCIDENTS DUE TO EXPLOSIVES AND LIST OF PERMISSIBLE EXPLOSIVES TESTED TO MAY 31, 1920

BY

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PRODUCTION AND DISTRIBUTION OF EXPLOSIVES IN THE UNITED STATES DURING THE CALENDAR YEAR 1919.

By William W. Adams.

INTRODUCTION.

The total production (excluding exports) of explosives in the United States during the year ended December 31, 1919, according to reports that the Bureau of Mines has received from manufacturers, was 417,634,470 pounds as compared with 499,124,660 pounds in 1918, a decrease of 81,490,190 pounds or 16 per cent.

The production for 1919 is segregated as follows: Black blasting powder, 180,511,050 pounds; "high" explosives other than permissible explosives, 198,268,588 pounds; and permissible explosives, 38,854,832 pounds. As compared with 1918, these figures represent a decrease of nearly 27 per cent for black powder, about 4 per cent for high explosives, and 15.5 per cent for permissible explosives.

The decrease in the output of explosives was due almost entirely to the fact that the coal and metal mining industries (which usually consume about 90 per cent of the annual production of black powder and permissible explosives and 60 per cent of all other high explosives) during 1919 used 84,700,000 pounds of explosives less than in 1918. The production of coal in 1919 was 20 per cent (134,000,000 short tons) less than the year before, and there was also a marked lessening of activity in metal mining, so that the decline in the production of explosives is readily explained by the conditions in the mining industry during the year.

CLASSIFICATION OF EXPLOSIVES.

The production figures tabulated herein are classified as follows:

1. *Black blasting powder.*—All black powder with sodium or potassium nitrate as a constituent is here classified as black blasting powder.

2. *High explosives.*—Dynamite and all other high explosives of various trade names and compositions, except permissible explosives, are put in this class.

3. *Permissible explosives.*—In this class are included ammonium nitrate explosives, hydrated explosives, organic nitrate explosives, and certain nitroglycerin explosives containing an excess of free water or carbon. All permissible explosives have passed certain tests of the Bureau of Mines and are not to be regarded as permissible unless used in the manner specified by the bureau.[1]

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[1] Hall, Clarence, Snelling, W. O., and Howell, S. P., Investigations of explosives used in coal mines, with a chapter on the natural gas used at Pittsburgh, by G. A. Burrell, and an introduction by C. E. Munroe: Bull. 15, Bureau of Mines, 1912, 197 pp. Hall, Clarence, and Howell, S. P., Tests of permissible explosives: Bull. 66, Bureau of Mines, 1913, 313 pp.

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SCOPE OF STATISTICS.

Table 1 gives the quantity of explosives used in each State during the calendar years 1918 and 1919. Tables 2, 3, and 4 present the total production and uses, by groups of States, of black blasting powder, high explosives, and permissible explosives, the States being grouped so as to include regions where the general conditions of mining are roughly similar.

Table 5 shows the annual production and sale of permissible explosives for use in coal mines. In 1902, only 11,300 pounds of short-flame or "safety" explosives were used in coal mining, whereas in 1919 the quantity of permissible explosives so used was 32,840,196 pounds. In a parallel column is also shown the annual production of coal in the United States.

The quantity of permissible explosives used in the United States is larger than that of the corresponding explosives used in a number of foreign countries. In 1912 it represented about 5 per cent of the total quantity of explosives produced in this country, and in 1919 9.3 per cent. The total amount of explosives used for the production of coal in 1919 was 215,946,704 pounds, of which 15 per cent was of the permissible class.

Table 6 gives the quantities of permissible explosives used for coal mining in the different coal fields. Table 11 shows that in 1919 about 85 per cent of the permissible explosives manufactured were used for coal mining. The remaining 15 per cent is reported under the items "Other mining," "Railway and construction work," and "All other purposes," in Tables 4 and 11.

The figures for 1919 represent the reports of 26 manufacturers who operated their various plants during the year. Many of the manufacturers operated more than one plant, so that the number of manufacturers does not indicate the total number of plants. The number of manufacturers reporting sales of black powder was 21; of high explosives, 19; and of permissible explosives, 12. A number of other companies reported their plants as idle during the year, or as having been sold to other manufacturers.

The reports of manufacturers of fireworks and of ammunition are not included, inasmuch as the majority of these manufacturers purchase their explosives from one or more of the manufacturers of explosives whose production has been included in the tabulations presented herein.

PRODUCTION AND DISTRIBUTION OF EXPLOSIVES.

The production and use of explosives in the United States are given in detail in Tables 1 to 6, following.

TABLE 1.—*Amount of explosives (excluding exports) manufactured in the United States and used in the various States during the calendar years 1918 and 1919.*

State.	1918			1919		
	Black blasting powder.	High explosives other than permissible.	Permissible explosives.	Black blasting powder.	High explosives other than permissible.	Permissible explosives.
	Kegs.	*Pounds.*	*Pounds.*	*Kegs.*	*Pounds.*	*Pounds.*
Alabama	173,481	5,948,814	4,434,380	137,390	5,069,614	2,983,250
Alaska	178	2,213,600	41,200	1,730	3,145,950	1,000
Arizona	18,833	13,124,525	15,600	27,900	10,067,700	3,650
Arkansas	105,768	826,461	103,400	70,027	1,530,937	98,805
California	43,538	8,517,684	1,600	69,375	10,962,816	....
Colorado	92,975	4,902,915	903,550	82,246	4,290,280	620,360
Connecticut	317	420,500	....	748	472,967	....
Delaware	66	50,075	1,000	23	58,171	....
Florida	407	1,233,100	32,625	1,225	1,190,925	10,400
Georgia	18,891	752,200	350	10,011	650,384	51,850
Idaho	5,857	2,874,630	4,550	14,409	3,029,425	3,000
Illinois	1,998,235	3,693,422	2,664,400	1,225,049	3,939,370	2,284,240
Indiana	1,095,128	1,471,302	356,596	725,912	1,859,220	301,925
Iowa	344,684	1,427,080	975	250,314	1,665,768	20,500
Kansas	502,095	5,220,869	59,152	346,528	5,293,369	135,405
Kentucky	600,791	1,812,676	1,142,620	493,417	1,742,723	1,151,774
Louisiana	367	691,640	72,474	88	603,131	136,327
Maine	1,180	324,350	....	1,663	450,376	....
Maryland and District of Columbia	45,787	1,126,770	89,300	28,625	1,148,911	65,700
Massachusetts	1,337	387,250	....	3,090	557,275	100
Michigan	20,907	24,994,152	23,600	7,546	22,703,853	6,500
Minnesota	179,045	9,941,860	....	143,714	9,664,132	200
Mississippi	48	299,500	1,150	4,220	388,022	30,600
Missouri	219,571	9,120,244	168,904	136,069	6,432,898	251,290
Montana	112,033	8,216,874	51,100	83,175	5,461,872	43,670
Nebraska	2,314	88,710	....	2,252	158,075	500
Nevada	11,507	4,733,025	500	21,126	3,240,840	1,300
New Hampshire	189	136,425	....	503	144,499	....
New Jersey	1,956	2,227,130	16,600	2,179	2,338,695	9,675
New Mexico	7,913	2,576,310	775,250	8,066	2,870,410	522,900
New York	14,551	6,016,836	466,150	12,913	6,933,533	544,025
North Carolina	12,283	1,094,925	900	9,632	1,479,451	2,250
North Dakota	21,343	286,525	3,425	21,507	270,025	200
Ohio	597,232	6,521,085	35,869	385,331	5,447,754	124,784
Oklahoma	196,083	8,955,527	1,102,775	104,391	9,426,729	914,856
Oregon	22,902	2,816,684	1,150	32,453	3,421,502	550
Pennsylvania	2,211,094	34,797,146	20,061,997	1,821,721	33,386,218	18,760,337
Rhode Island	172	80,550	....	125	97,125	....
South Carolina	1,523	411,925	....	794	266,931	100
South Dakota	2,121	1,199,535	....	2,760	772,654	....
Tennessee	157,435	2,487,005	598,089	117,095	2,807,299	304,050
Texas	44,380	[1] 1,106,020	28,200	50,976	1,355,414	109,165
Utah	27,211	3,610,556	4,430,820	24,538	3,573,638	2,142,760
Vermont	2,297	180,075	....	2,147	181,025	200
Virginia	113,837	2,589,058	499,025	89,035	2,319,029	381,776
Washington	49,647	5,934,194	427,800	28,131	5,461,938	484,750
West Virginia	656,467	3,511,835	6,812,657	514,969	3,454,319	6,040,388
Wisconsin	2,380	5,045,653	25,000	3,007	6,077,271	3,000
Wyoming	128,178	416,850	590,500	100,297	404,125	306,720
Total	[2] 9,866,534	206,416,077	46,045,233	[2] 7,220,442	198,268,588	38,854,832
	[3] 246,663,350	....	....	[3] 180,511,050	....	....
Grand total (pounds).	**499,124,660**			**417,634,470**		

[1] Revised 100,000 pounds.

[2] Kegs of 25 pounds each.

[3] Pounds.

TABLE 2.—*Amount of black blasting powder used in the United States during 1918 and 1919, classified by use.*

[Kegs of 25 pounds each.]

Groups of States.	Black blasting powder, 1918.				Black blasting powder, 1919.			
	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.
	Kegs.	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*	*Kegs.*
Group 1. Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont	....	242	75	4,858	....	....	44	7,484
Group 2. Connecticut, New Jersey, and New York	....	3,056	763	13,005	....	1,927	233	13,680
Group 3. Delaware, District of Columbia, Maryland, and Virginia	143,028	1,747	4,875	10,040	103,616	1,526	1,828	10,713
Pennsylvania	1,902,309	4,705	34,689	269,391	1,622,434	12,880	7,663	178,744
West Virginia	614,841	2,400	9,116	30,110	476,552	2,465	7,448	28,504
Group 4. Florida, Georgia, North Carolina, and South Carolina	1,095	5,112	19,538	7,359	1,770	2,621	8,294	8,977
Group 5. Indiana and Kentucky	1,605,775	7,330	10,811	72,003	1,149,023	7,800	5,498	57,008
Illinois	1,950,587	9,014	153	38,481	1,163,311	4,831	742	56,165
Ohio	519,006	18,327	4,045	55,854	345,594	9,676	1,031	29,030
Group 6. Alabama, Mississippi, and Tennessee	279,771	9,836	22,556	18,801	213,523	7,998	15,378	21,806
Group 7. Michigan, Minnesota, and Wisconsin	13,377	180,826	681	7,448	5,259	143,750	762	4,496
Group 8. Iowa, Kansas, Missouri, and Nebraska	1,009,672	9,390	8,057	41,545	652,243	9,190	5,504	68,226
Group 9. Arkansas, Louisiana, Oklahoma, and Texas	309,729	8,642	10,228	17,999	186,356	1,625	14,976	22,525
Group 10. Montana, North Dakota, South Dakota, and Wyoming	206,104	10,380	9,023	38,168	135,152	11,832	5,024	55,731
Group 11. Colorado, New Mexico, and Utah	72,935	10,031	10,344	34,789	70,947	4,010	16,802	23,091
Group 12. Alaska, Idaho, Oregon, and Washington	20,633	1,374	37,909	18,668	13,825	2,337	38,153	22,408
Group 13. Arizona, California, and Nevada	....	15,406	36,397	22,075	....	27,666	74,817	15,918
Total (kegs)	8,648,862	297,818	219,260	700,594	6,139,605	252,134	204,197	624,506
Grand total (kegs)	**9,866,534**				**7,220,442**			

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TABLE 3.—*Amount of high explosives used in the United States during 1918 and 1919, classified by use.*

Groups of States.	High explosives other than permissible explosives, 1918.				High explosives other than permissible explosives, 1919.			
	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Group 1. Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont	....	74,050	172,675	861,925	....	69,825	167,074	1,202,401
Group 2. Connecticut, New Jersey, and New York	....	4,241,350	869,469	3,553,647	....	4,590,189	853,659	4,301,347
Group 3. Delaware, District of Columbia, Maryland, and Virginia	633,925	446,300	537,500	2,148,178	496,313	415,700	278,246	2,335,852
Pennsylvania	19,568,436	452,970	1,355,697	13,420,043	20,238,531	434,857	670,966	12,041,864
West Virginia	971,795	7,050	463,017	2,069,973	1,013,594	17,750	472,982	1,949,993
Group 4. Florida, Georgia, North Carolina, and South Carolina	29,200	722,775	951,405	1,788,770	2,400	662,393	650,966	2,271,932
Group 5. Indiana and Kentucky	896,480	174,375	622,350	1,590,773	785,207	193,555	487,339	2,135,842
Illinois	581,553	1,331,150	98,325	1,682,394	460,494	1,384,725	160,147	1,934,004
Ohio	855,501	261,692	496,552	4,907,340	613,189	218,400	311,852	4,304,313
Group 6. Alabama, Mississippi, and Tennessee	1,701,275	4,141,965	1,305,323	1,586,756	1,413,175	4,224,359	876,998	1,750,403
Group 7. Michigan, Minnesota, and Wisconsin	116,150	33,970,850	363,300	5,531,365	110,700	30,235,578	354,589	7,744,389
Group 8. Iowa, Kansas, Missouri, and Nebraska	3,534,428	9,328,112	535,067	2,459,296	3,159,155	6,815,910	525,640	3,049,405
Group 9. Arkansas, Louisiana, Oklahoma, and Texas	532,965	8,462,225	575,229	2,009,229	483,805	8,751,850	788,133	2,892,423
Group 10. Montana, North Dakota, South Dakota, and Wyoming	1,095,760	7,569,980	78,834	1,375,210	323,935	5,737,175	51,920	795,646
Group 11. Colorado, New Mexico, and Utah	251,480	6,739,745	81,760	4,016,796	272,235	6,640,958	118,910	3,702,225
Group 12. Alaska, Idaho, Oregon, and Washington	599,125	4,326,500	2,031,645	6,881,838	243,650	4,699,050	2,407,420	7,708,695
Group 13. Arizona, California, and Nevada	....	20,115,787	1,543,393	4,716,054	....	14,671,[illegible]14	3,582,782	6,017,060
Total (pounds)	31,368,073	102,366,876	12,081,541	60,599,587	29,616,383	89,754,788	12,759,623	66,137,794
Grand total (pounds)	**206,416,077**				**198,268,588**			

TABLE 4.—*Amount of permissible explosives used in the United States during 1918 and 1919, classified by use.*

Groups of States.	Permissible explosives, 1918.				Permissible explosives, 1919.			
	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Group 1. Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont	....	....	....	....	....	....	....	300
Group 2. Connecticut, New Jersey, and New York	....	465,650	500	16,600	....	543,000	550	10,150
Group 3. Delaware, District of Columbia, Maryland, and Virginia	489,250	24,050	550	75,475	333,176	27,350	1,300	85,650
Pennsylvania	18,256,206	3,600	22,925	1,779,266	17,527,997	2,200	950	1,229,190
West Virginia	5,902,357	12,550	26,350	871,400	5,343,491	38,200	37,135	621,562
Group 4. Florida, Georgia, North Carolina, and South Carolina	900	100	....	32,875	50	600	....	63,950
Group 5. Indiana and Kentucky	1,335,716	10,500	....	153,000	1,389,949	13,550	3,500	46,700
Illinois	2,609,300	42,700	....	12,400	2,257,815	18,050	300	8,075
Ohio	13,806	5,500	....	16,563	1,350	....	....	123,434
Group 6. Alabama, Mississippi, and Tennessee	4,692,616	250,930	15,630	74,443	3,104,660	29,767	51,028	132,445
Group 7. Michigan, Minnesota, and Wisconsin	200	14,600	....	33,800	....	3,100	....	6,600
Group 8. Iowa, Kansas, Missouri, and Nebraska	18,130	38,900	8,500	163,501	48,970	100,700	5,650	252,375
Group 9. Arkansas, Louisiana, Oklahoma, and Texas	912,314	201,500	800	192,235	593,968	382,045	3,790	279,350
Group 10. Montana, North Dakota, South Dakota, and Wyoming	568,850	18,850	5,275	52,050	252,020	29,470	....	69,100
Group 11. Colorado, New Mexico, and Utah	2,053,670	3,427,950	60,350	567,650	1,630,750	1,252,500	59,150	343,620
Group 12. Alaska, Idaho, Oregon, and Washington	408,950	16,350	42,500	6,900	356,000	52,650	20,000	60,650
Group 13. Arizona, California, and Nevada	650	16,400	....	650	....	4,950	....	....
Total (pounds)	37,262,915	4,550,130	183,380	4,048,808	32,840,196	2,498,132	183,353	3,333,151
Grand total (pounds)	**46,045,233**				**38,854,832**			

TABLE 5.—*Yearly sales of short-flame explosives used in coal mines in the United States 1901–1919, and contemporaneous production of coal.*

Year.	Production of coal (short tons).	Quantity sold.	Year.	Production of coal (short tons).	Quantity sold.
		Pounds.			*Pounds.*
1901	293,299,816	....	1911	496,371,126	13,428,239
1902	301,590,434	11,300	1912	534,466,580	18,150,618
1903	357,356,416	288,661	1913	570,048,125	21,804,285
1904	351,816,398	608,270	1914	513,525,477	19,593,892
1905	392,722,635	1,031,300	1915	531,619,487	21,841,659
1906	414,157,278	1,533,575	1916	590,098,175	26,566,521
1907	480,363,424	2,095,244	1917	651,402,374	32,910,397
1908	415,842,698	2,108,610	1918	678,211,904	37,262,915
1909	460,814,616	8,942,857	1919	[1] 544,263,000	32,840,196
1910	501,596,378	11,820,836			

[1] Estimated.

TABLE 6.—*Quantity of permissible explosives used in different coal fields in the United States, 1912–1919.*

Coal fields and regions.	1912	1913	1914	1915
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1. Pennsylvania anthracite field	2,177,172	3,294,225	4,380,635	5,037,050
2. Northern Appalachian region [1]	9,190,025	9,744,810	7,966,464	9,435,318
3. Southern Appalachian region	3,995,485	4,481,975	3,510,013	3,447,964
4. Eastern interior field	751,005	2,058,075	1,364,450	1,631,775
5. Western interior field	440,825	377,625	411,937	433,010
6. Rocky Mountain region	1,473,129	1,634,575	1,796,750	1,710,992
7. Pacific coast region	122,977	213,000	163,643	145,550
Total	**18,150,618**	**21,804,285**	**19,593,892**	**21,841,659**

Coal fields and regions.	1916	1917	1918	1919
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
1. Pennsylvania anthracite field	5,219,032	7,298,925	7,654,250	8,579,643
2. Northern Appalachian region [1]	12,147,207	14,505,542	17,007,369	14,626,371
3. Southern Appalachain region	4,386,757	5,287,755	5,764,886	4,210,184
4. Eastern interior field	1,949,925	2,403,600	2,873,846	2,542,290
5. Western interior field	422,425	624,045	930,444	642,938
6. Rocky Mountain region	2,244,275	2,423,180	2,622,520	1,882,770
7. Pacific coast region	196,900	367,350	409,600	356,000
Total	**26,566,521**	**32,910,397**	**37,262,915**	**32,840,196**

[1] Not including Pennsylvania anthracite field.

TABLE 7.—*Coal-mine fatalities due to explosives, 1911–1919.*

States.	1911	1912	1913	1914	1915	1916	1917	1918	1919
Pennsylvania	94	85	79	97	88	96	62	56	[1] 166
West Virginia	3	8	8	5	6	3	6	14	6
Illinois	15	11	11	9	11	6	9	12	2
Ohio	3	5	6	2	3	5	4	8	10
Indiana, Michigan, and Kentucky	15	3	5	12	12	10	14	20	11
Alabama, Tennessee, Georgia, and North Carolina	6	6	2	2	10	3	3	5	3
Iowa, Kansas, and Missouri	4	14	6	4	13	9	2	7	2
Colorado, New Mexico, and Utah	3	1	7	4	......	4	3	3	1
Maryland and Virginia	......	10	2	......	4	3	2	5	2
Montana, North Dakota, and Wyoming	4	2	4	4	3	2	2	1	2
Arkansas, Oklahoma, and Texas	11	1	5	4	5	1	4	4	......
Alaska, California, Idaho, Nevada, Oregon, and Washington	2	1	3	3	......	4	......	......	1
Total, underground	**160**	**147**	**138**	**146**	**155**	**146**	**111**	**135**	**206**

[1] Of this number, 92 men were killed in the powder explosion in Baltimore Tunnel No. 2, Wilkes-Barre, Pa., on June 5, 1919.

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FATALITIES IN THE MINING INDUSTRY DUE TO EXPLOSIVES.

Tables 7, 8, 9, and 10 present the number of fatalities from the use of explosives in the mining industry. Inasmuch as 80 per cent of the amount of permissible explosives used in coal mines is used in bituminous mines, it is interesting to compare Tables 8 and 5, for the former gives the decreased fatality rate and the latter the increased amount of permissible explosives used in and about coal mines. In 1903, 9.8 per cent of the fatalities at bituminous mines were caused by explosives, whereas in 1919 only 3.4 per cent were due to this cause.

Table 9 shows that 9 to 14 per cent of the metal-mine fatalities, 16 to 26 per cent of the quarry fatalities, and 4 to 7 per cent of the coal-mine fatalities were from explosives.

TABLE 8.—*Fatalities due to explosives at bituminous coal mines, 1903–1919.*

Year.	Number killed.	Percentage of total killed.	Number killed per 1,000 employed.
1903	138	9.80	0.339
1904	121	8.64	.290
1905	119	7.49	.264
1906	115	7.27	.246
1907	134	5.29	.264
1908	109	6.17	.216
1909	122	5.88	.244
1910	113	5.09	.203
1911	72	3.68	.130
1912	70	3.85	.128
1913	63	2.91	.110
1914	56	3.01	.096
1915	76	4.52	.136
1916	60	3.59	.107
1917	55	2.60	.091
1918	85	4.19	.138
1919	57	3.41	....

TABLE 9.—*Number and percentage of fatalities due to explosives, at metal mines and quarries in the United States, 1911–1918.*

Year.	Metal mines.		Quarries.		Coal mines.	
	Number.	*Per cent.*	*Number.*	*Per cent.*	*Number.*	*Per cent.*
1911	78	11.22	50	26.60	160	6.02
1912	94	14.22	47	22.06	147	6.08
1913	89	13.03	44	24.04	138	4.95
1914	60	10.73	35	19.44	146	5.95
1915	78	14.10	28	18.92	155	6.83
1916	89	12.77	28	16.18	146	6.56
1917	79	9.27	21	16.03	111	4.12
1918	89	13.78	17	13.60	135	5.24

TABLE 10.—*Fatal accidents due to explosives in the mineral industry, 1918.*

	Transportation.	Charging.	Suffocation.	Drilling into old holes.	Striking into loose rock or ore.	Thawing.	Caps, detonators, etc.	Unguarded shots.	Returned too soon.	Premature shots.	Sparks from match, lamp, or candle.	Delayed blast.	Shot breaking through rib or pillar.	Miscellaneous.	Total.
Quarries	....	4	....	1	....	....	....	1	1	6	....	....	....	4	17
Coal mines (underground)	4	13	4	2	1	....	3	....	18	44	13	4	9	20	135
Metal mines (underground)	....	1	....	3	2	....	....	....	....	8	....	....	....	4	[1] 18
Metal mines (open pit)	....	3	....	....	....	....	....	....	....	5	....	....	....	2	[1] 10
Total	4	21	4	6	3	....	3	1	19	63	13	4	9	30	180

[1] From selected returns only. Details as to subdivisions not available for all metal mines. See Table 9.

TABLE 11.—*Percentage of explosives used for various purposes in the United States during 1915, 1916, 1917, 1918, and 1919.*

	Coal mining.	Other mining.	Railway and other construction work.	All other purposes.	Total.
1919.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Black blasting powder	85.0	3.5	2.8	8.7	100.00
High explosives	14.9	45.3	6.4	33.4	100.00
Permissible explosives	84.5	6.4	.5	8.6	100.00
Total	**51.7**	**23.6**	**4.3**	**20.4**	**100.00**
1918.					
Black blasting powder	87.7	3.0	2.2	7.1	100.00
High explosives	15.2	49.6	5.8	29.4	100.00
Permissible explosives	80.9	9.9	.4	8.8	100.00
Total	**57.1**	**22.9**	**3.5**	**16.5**	**100.00**
1917.					
Black blasting powder	85.1	3.4	4.7	6.8	100.0
High explosives	10.8	50.4	7.8	31.0	100.0
Permissible explosives	76.5	14.2	.2	9.1	100.0
Total	**51.0**	**25.4**	**5.7**	**17.9**	**100.0**
1916.					
Black blasting powder	82.1	3.6	5.0	9.3	100.0
High explosives	8.2	51.6	8.6	31.6	100.0
Permissible explosives	76.6	17.9	.3	5.2	100.0
Total	**44.4**	**28.8**	**6.5**	**20.3**	**100.0**
1915.					
Black blasting powder	84.8	3.4	3.6	8.2	100.0
High explosives	9.5	46.3	9.4	34.9	100.1
Permissible explosives	79.9	17.1	.5	2.5	100.0
Total	**45.9**	**26.1**	**6.4**	**21.5**	**99.9**

DISTRIBUTION OF EXPLOSIVES BY PRINCIPAL INDUSTRIES.

Table 11 shows the percentages of black blasting powder, high explosives, and permissible explosives used in the various branches of the mining industry. For example, in 1919, 85 per cent of the black blasting powder was used in mining coal and only 3.5 per cent for other mining. In 1919, the mining industry of the United States used 75.3 per cent of all the explosives produced in this country, as compared with 80 per cent in 1918. Of the total amount of permissible explosives used in 1919, 84.5 per cent was used in coal mining and 6.4 per cent for other mining. Of high explosives other than permissible explosives, only a small percentage of the production is used for mining coal, and 45 per cent is used for other mining.

PRODUCTION OF EXPLOSIVES, 1912 TO 1919.

Table 12 and figure 1, based on that table, show the quantity of explosives produced annually in the United States from 1912 to 1919, as well as the purpose for which the explosives were used. During the eight-year period the total output of explosives was as follows: Black blasting powder 71,356,914 kegs of 25 pounds each; permissible explosives 267,989,794 pounds; high explosives other than permissible explosives, 1,853,294,126 pounds. Of this production the coal-mining industry consumed 59,950,907 kegs of black powder, representing 84 per cent of the entire output; 210,970,483 pounds of permissible explosives, representing 79 per cent; and 201,795,201 pounds of other high explosives, or less than 11 per cent. The metal-mining industry consumed a relatively small amount of permissible explosives and black blasting powder, but used 831,303,877 pounds of high explosives or about 45 per cent of the total production during the eight-year period.

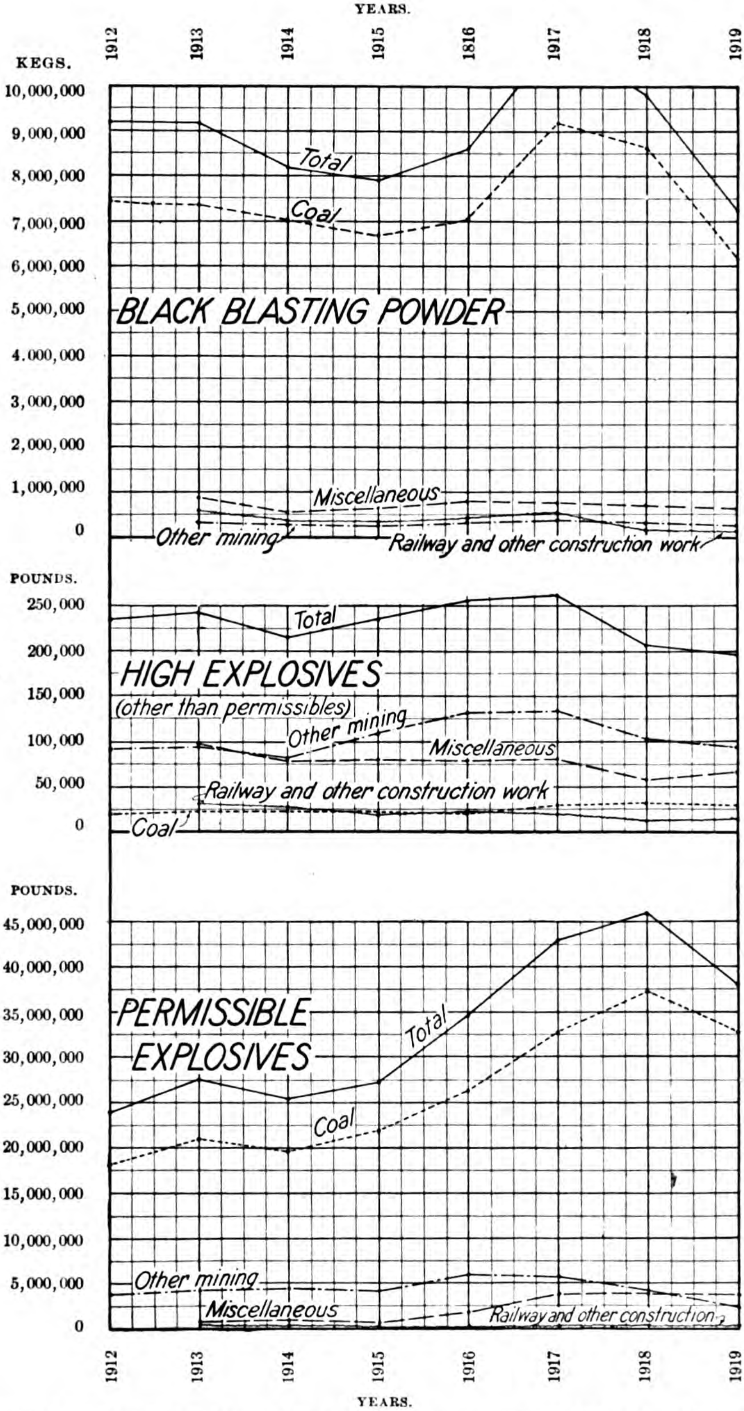

FIGURE 1.—Production of explosives, by classes, 1912–1919, and purpose for which each class is used.

TABLE 12.—*Production of explosives in the United States from 1912 to 1919.*

[Excluding exports.]

	1912	1913	1914	1915	1916	1917	1918	1919
Black Blasting Powder (kegs of 25 pounds):								
Quantity used for coal mining	7,483,640	7,396,683	7,072,506	6,700,558	7,079,041	9,430,012	8,648,862	6,139,605
Quantity used for other mining	1,728,095	334,014	302,885	268,146	313,851	378,199	297,818	252,134
Quantity used for railway and other construction work		626,474	316,131	289,869	428,853	516,892	219,260	204,197
Quantity used for all other purposes		840,410	552,466	650,319	801,256	759,638	700,594	621,506
Total	**9,211,735**	**9,197,581**	**8,243,988**	**7,908,892**	**8,623,001**	**11,084,741**	**9,866,534**	**7,220,442**
High Explosives other than Permissible (pounds):								
Quantity used for coal mining	20,903,430	24,143,133	24,215,945	22,384,025	20,901,405	28,262,807	31,368,073	29,616,383
Quantity used for other mining	89,703,081	92,096,426	84,264,577	109,128,966	131,753,648	132,235,515	102,366,876	89,754,788
Quantity used for railway and other construction work	123,862,981	33,173,805	27,983,946	22,279,699	21,905,376	20,418,227	12,081,541	12,759,623
Quantity used for all other purposes		92,973,180	81,989,503	82,035,897	80,594,358	81,399,531	60,599,587	66,137,794
Total	**234,469,492**	**242,386,544**	**218,453,971**	**235,828,587**	**255,154,787**	**262,316,080**	**206,416,077**	**198,268,588**
Permissible Explosives (pounds):								
Quantity used for coal mining	18,150,618	21,804,285	19,593,892	21,841,659	26,566,521	32,910,397	37,262,915	32,840,196
Quantity used for other mining	4,668,399	4,735,480	4,850,241	4,687,510	6,206,558	6,102,225	4,550,130	2,498,132
Quantity used for railway and other construction work	1,811,253	424,575	281,425	139,843	97,100	106,185	183,380	183,353
Quantity used for all other purposes		721,430	972,260	680,897	1,815,061	3,921,915	4,048,808	3,333,151
Total	**24,630,270**	**27,685,770**	**25,697,818**	**27,349,909**	**34,685,240**	**43,040,722**	**46,045,233**	**38,854,832**

EXPORTS OF EXPLOSIVES, 1913–1919.

Table 13 shows the amount and value of explosives exported from the United States during the years 1913 to 1919, inclusive. The tabulations of exports unfortunately do not segregate such explosives as picric acid, nitroglycerin, trinitrotoluene, and others. These are grouped in the column headed "All other."

TABLE 13.—*Explosives exported from the United States, 1913–1919.*[1]

Years and months.	Cartridges.	Dynamite.		Gunpowder.		All other.	Total.
	Value.	Pounds.	Value.	Pounds.	Value.	Value.	Value.
Total, 1913	**$3,015,399**	**13,399,616**	**$1,498,222**	**1,284,422**	**$359,855**	**$651,601**	**$5,525,077**
Total, 1914	**6,567,122**	**11,296,115**	**1,213,600**	**896,569**	**291,453**	**1,965,412**	**10,037,587**
Total, 1915	**25,408,079**	**11,446,368**	**1,509,050**	**84,358,379**	**66,922,807**	**95,129,957**	**188,969,893**
Total, 1916	**55,103,904**	**18,681,285**	**4,173,175**	**303,648,981**	**262,161,893**	**394,136,334**	**715,575,306**
Total, 1917	**42,122,656**	**17,930,665**	**3,953,374**	**438,459,254**	**337,904,687**	**255,954,207**	**639,934,405**
1918.							
January	2,438,334	2,606,297	764,677	47,230,343	37,587,662	2,992,420	43,783,093
February	76,811	1,886,938	477,170	22,120,121	16,671,446	3,533,682	20,759,109
March	1,139,778	1,715,645	713,879	23,847,376	19,224,301	2,611,238	23,689,196
April	2,028,948	1,663,368	440,646	15,924,869	12,927,166	7,620,916	23,017,676
May	388,671	724,900	166,703	9,738,388	6,800,933	4,697,478	12,053,785
June	200,718	1,831,645	414,330	6,907,838	6,322,346	3,870,328	10,807,722
July	1,328,328	1,532,963	383,389	11,955,068	9,172,949	6,039,123	16,923,789
August	765,910	523,400	137,756	18,004,450	13,279,069	3,902,620	18,085,355
September	199,387	2,240,600	519,976	41,959,721	34,667,955	6,738,675	42,125,993
October	1,315,296	790,150	185,850	17,834,972	15,662,181	4,992,588	22,155,915
November	271,029	1,039,178	225,908	13,691,014	7,260,214	475,268	8,232,419
December	611,555	1,649,560	415,604	162,898	71,934	795,394	1,894,487
Total	**10,764,765**	**18,204,644**	**4,845,888**	**229,377,058**	**179,648,156**	**48,269,730**	**243,528,539**
1919.							
January	311,519	1,709,120	429,231	12,638	10,345	475,229	1,226,324
February	295,108	954,445	222,915	109,324	59,227	464,857	1,042,107
March	1,896,511	509,646	108,192	118,494	70,322	301,504	2,376,529
April	395,470	678,412	126,181	96,702	45,466	176,001	743,118
May	483,759	803,486	179,476	5,508,489	5,444,565	233,233	6,341,033
June	902,864	1,094,136	255,969	159,395	67,984	356,991	1,583,808
July	470,541	518,260	91,534	33,951	17,976	167,436	747,487
August	4,014,279	1,251,520	246,918	201,296	60,556	335,558	4,657,311
September	428,398	1,321,660	233,114	92,428	38,396	269,049	968,957
October	345,302	635,976	139,895	97,001	39,635	139,533	664,365
November	397,455	978,464	184,559	76,132	35,092	6,388,998	7,006,104
December	405,751	718,403	152,032	245,949	101,180	383,601	1,042,564
Total	**10,346,957**	**11,173,528**	**2,370,016**	**6,751,799**	**5,990,744**	**9,691,990**	**28,399,707**

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[1] Compiled from "Monthly Summary of Foreign Commerce of the United States," published by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Original from PRINCETON UNIVERSITY

Table 14 shows the amount and value of explosives exported from the United States during 1919, by countries. It will be noted that no explosives were exported to Germany, Austria, Bulgaria, and Turkey.

TABLE 14.—*Explosives exported from the United States, by countries in 1919.*[1]

Countries.	Cartridges.	Dynamite.		Gunpowder.		All other.	Total.
	Value.	Pounds.	Value.	Pounds.	Value.	Value.	Value.
Roumania	...	...	...	...	...	$6,064,640	$6,064,640
United Kingdom	$100,669	...	...	5,393,607	$5,393,243	102,185	5,596,097
Russia in Europe	3,516,300	...	...	100,000	28,000	...	3,544,300
Russia in Asia	180,645	...	...	1,135	638	656	181,939
Mexico	99,283	6,303,185	$1,188,234	85,830	17,769	503,109	1,808,395
Denmark	1,416,767	...	...	...	...	592	1,417,359
Brazil	674,657	363,971	101,993	1,577	1,171	378,748	1,156,569
Australia	801,867	...	...	29,568	9,086	244,800	1,055,753
Chile	153,176	1,305,422	328,618	4,681	1,725	334,800	818,319
Argentina	552,137	177,500	59,584	145,109	70,878	101,721	784,320
Canada	341,054	89,639	33,103	156,883	98,507	240,187	712,851
Cuba	213,248	815,650	180,868	115,030	31,635	166,559	592,310
Peru	212,959	294,184	61,357	19,405	19,137	201,730	495,183
Italy	485,545	...	...	...	...	662	486,207
British Africa	231,994	...	...	137,510	55,872	66,802	354,668
Colombia	89,564	42,950	12,380	106,645	43,233	123,405	268,582
Sweden	51,664	...	...	...	...	193,479	245,143
Philippine Islands	116,817	235,000	46,228	7,280	3,894	44,686	211,625
British India	174,572	130	48	...	...	25,916	200,536
New Zealand	133,334	675	211	55,560	4,525	38,936	177,006
Bolivia	35,523	130,000	34,058	12,860	7,664	79,985	157,230
Japan	9,658	89,670	9,191	350	213	137,544	156,606
Norway	52,305	...	...	...	...	103,274	155,579
China	106,920	1,139	708	36,000	29,958	12,236	149,822
Nicaragua	37,265	238,300	53,153	33,401	17,757	26,752	134,927
Panama	20,383	196,500	56,424	26,250	10,429	24,509	111,745
Honduras	8,097	309,400	61,327	30,540	10,793	27,976	108,193
Venezuela	22,350	400	280	88,968	64,370	21,079	108,079
Salvador	48,172	181,000	32,196	7,525	3,752	19,212	103,332
France	3,905	...	...	...	...	91,341	95,246
Uruguay	69,102	...	...	...	...	19,085	88,187
Spain	68,481	...	...	...	...	13,832	82,313
Greece	60,375	...	...	...	...	14,103	74,478
Ecuador	29,308	25,500	4,379	56,784	21,764	13,494	68,945
Egypt	1,668	...	...	...	...	56,842	58,510
Belgium	21,957	...	...	...	...	8,821	30,778
Newfoundland and Labrador	21,254	...	...	...	...	9,445	30,699
Costa Rica	488	70,000	14,785	13,622	4,713	5,928	25,914
Portugal	9,429	...	...	100	37	15,766	25,232
Guatemala	311	18,500	4,900	27,500	9,218	4,421	18,850
Paraguay	8,805	...	...	...	...	201	9,006
Netherlands	5,036	...	...	...	...	625	5,661
Switzerland	1,950	...	...	...	...	...	1,950
Austria-Hungary	...	...	...	...	...	...	...
Bulgaria	...	...	...	...	...	...	...
Germany	...	...	...	...	...	...	...
Turkey in Europe	...	...	...	...	...	...	...
Turkey in Asia	...	...	...	...	...	...	...
All other countries	157,963	284,813	85,991	58,079	30,763	151,906	426,623
Total	10,346,957	11,173,528	2,370,016	6,751,799	5,990,744	9,691,990	28,399,707

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[1] Compiled from "Monthly Summary of Foreign Commerce of the United States," published by the Bureau of Foreign and Domestic Commerce, Department of Commerce.

PERMISSIBLE EXPLOSIVES TESTED TO MAY 31, 1920.

By SPENCER P. HOWELL.

GENERAL STATEMENT.

In the table following are the brand names of all explosives now considered as permissible explosives that were tested by the Bureau of Mines to May 31, 1920.

Further information on permissible explosives may be found in other Bureau of Mines publications.[1] The precautions to be observed in the handling, storage, and use of permissible explosives are found in Miner's Circular 6. The conditions to be fulfilled by applicants desiring explosives tested to determine their permissibility for use in coal mines are stated in Schedule 1. A description of the tests made, the apparatus used for such tests, and detailed results of tests of 100 permissible explosives are given in Bulletins 15 and 66. The storage, handling, and use of permissible explosives are discussed in Bulletins 10 and 17 and Miner's Circular 7, and the methods used by the bureau in the analysis of permissible explosives and the tolerances for permissible explosives as promulgated by the Bureau of Mines on July 1, 1915, are detailed in Bulletin 96. The tolerances established are also given on pages 37 and 38 of the present report.

There were 152 explosives on the permissible list on January 1, 1917.[2] During the succeeding 34 months 30 explosives were added to the list; 7 explosives were dropped (in most instances because the manufacturers no longer desired to market them) and are no longer designated permissible explosives. The present list takes the place of all preceding lists and includes a total of 175 explosives.

Addition to this list of permissible explosives will be published in future issues of the Monthly Statement of Coal-Mine Fatalities in the United States, which contains also lists of miners' electric lamps and other devices approved by the Bureau of Mines.

DEFINITION OF A PERMISSIBLE EXPLOSIVE.

An explosive is called a permissible explosive when it is similar in all respects to the sample that passed certain tests by the Federal Bureau of Mines, and when it is used in accordance with the conditions prescribed by this bureau. But even the explosives that have passed these tests and are named in this list as permissible explosives are to be considered permissible explosives only when used under the following conditions:

1. That the explosive is in all respects similar to the sample submitted by the manufacturer for test.

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[1] Hall, Clarence, Permissible explosives tested prior to Jan. 1, 1912, and precautions to be taken in their use: Miner's Circular 6, Bureau of Mines, 1912, 20 pp.: Fees for testing explosives: Schedule 1, Bureau of Mines, 1913; Hall, Clarence, Snelling, W. O., and Howell, S. P., Investigations of explosives used in coal mines: Bull. 15, Bureau of Mines, 1911, 191 pp.; Hall, Clarence, and Howell, S. P., Tests of permissible explosives: Bull. 66, Bureau of Mines, 1913, 313 pp.; Munroe, C. E., and Hall, Clarence, A primer on explosives for coal miners: Bull. 17, Bureau of Mines, 1911, 61 pp.; Rutledge, J. J., and Hall, Clarence, The use of permissible explosives: Bull. 10, Bureau of Mines, 1912, 34 pp.; Storm, C. G., The analysis of permissible explosives: Bull. 96, Bureau of Mines, 1916, 88 pp.; Rutledge, J. J., The use and misuse of explosives in coal mining: Miner's Circular 7, Bureau of Mines, 1913, 52 pp.; Howell, S. P., and Tiffany, J. E., Methods for routine work in the explosives physical laboratory of the Bureau of Mines: Tech. Paper 186, Bureau of Mines, 1918, 63 pp.

[2] Howell, S. P., Permissible explosives tested prior to Jan. 1, 1917: Tech. Paper 169, Bureau of Mines, 1917, 19 pp.

2. That detonators—preferably electric detonators—are used of not less efficiency than those prescribed, namely, those consisting by weight of 90 parts of mercury fulminate and 10 parts of potassium chlorate (or their equivalents).

3. That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use.

4. That the quantity used for a shot does not exceed 1½ pounds (680 grams), and that it is properly tamped with clay or other noncombustible stemming.

After an explosive has passed the required tests and its brand name has been published in a list of permissible explosives, it is not a permissible explosive if one or more of any of the following conditions prevail:

1. If kept in a moist place until it undergoes a change in character.
2. If used in a frozen or partly frozen condition.
3. If used in excess of 1½ pounds (680 grams) per shot.
4. If the diameter of the cartridge is less than that designated in the column "smallest permissible diameter".
5. If fired with a detonator or electric detonator of less efficiency than that prescribed.
6. If fired without stemming.
7. If fired with combustible stemming.

Moreover, even when all of the prescribed conditions have been met, no explosive on the permissible list should necessarily be considered as being *permanently* a permissible explosive, for the bureau reserves the right, on fuller information concerning the conditions that lead to safety, to revise this list; but any permissible explosive when used under the prescribed conditions may properly continue to be considered a permissible explosive until notice of its withdrawal or removal from the list has been officially published, or until its name is omitted from a later list published by the Bureau of Mines.

Furthermore, the manufacturers of a permissible explosive may withdraw it at any time. Manufacturers are urged to do so when replacing a permissible explosive by one of superior qualities, or when they permanently discontinue the manufacture of a permissible explosive.

After further experiments and conferences the Bureau of Mines may find it advisable to adopt additional and more severe tests to which all permissible explosives may be subjected, in the hope that through the use of such explosives only as pass the more severe tests the lives of miners may be better safeguarded.

LIST OF PERMISSIBLE EXPLOSIVES.

Subject to the conditions and provisions stated herein, the following explosives are classed as permissible explosives:

Permissible explosives tested to May 31, 1920.

Brand.	Class designation basis, volume of poisonous gases.	Class designation basis, characteristic ingredient.	When used with detonators, preferably electric detonators, of not less efficiency than—	Weight of 1¼ by 8 inch cartridge.	Smallest permissible diameter.	Unit deflective charge.	Rate of detonation in 1¼-inch diameter cartridges.		Manufacturer.
1	2	3	4	5	6	7	8		9
				Grams.	*Inches.*	*Grams.*	*Feet per second.*	*Meters per second.*	
Aetna coal powder A	C	4	No. 6	184	1¼	277	12,620	3,848	Aetna Explosives Co. (Inc.), New York, N. Y.
Aetna coal powder AA	A	1*a*	do	[1] 214	1¼	241	7,880	2,403	Do.
Aetna coal powder B	C	4	do	179	1¼	301	9,870	3,008	Do.
Aetna coal powder B+ [2]	C	do	do	192	1¼	288	9,760	2,977	Do.
Aetna coal powder C	B	do	do	198	1¼	344	7,010	2,138	Do.
Aetna coal powder 2	A	1*a*	do	186	1⅛	212	9,280	2,830	Do.
Bental coal powder No. 2	A	do	No. 7	180	1¼	276	4,750	1,447	Hercules Powder Co., Wilmington, Del.
Bental coal powder No. 2-X	A	do	No. 6	192	1¼	280	7,980	2,432	Do.
Big Red No. 1	B	do	do	171	⅞	240	7,250	2,209	The Equitable Powder Manufacturing Co., and the Egyptian Powder Co., East Alton Ill.
Big Red No. 2	B	do	do	166	⅞	255	10,850	3,309	Do.
Big Red No. 4, L. F	B	do	do	171	⅞	254	10,290	3,138	Do.
Big Red No. 5	A	do	do	182	⅞	260	7,490	2,284	Do.
Big Red No. 6, L. F	B	do	do	174	⅞	242	7,480	2,280	Do.
Big Red No. 7	A	do	do	186	⅞	227	10,000	3,050	Do.
Bituminite 1	C	4	do	187	1¼	318	12,800	3,901	Aetna Explosives Co. (Inc.), New York, N. Y.
Bituminite 4	C	do	do	178	1¼	301	7,540	2,298	Do.
Bituminite 5	A	1*a*	do	176	1¼	231	9,120	2,782	Do.
Bituminite 8, L. F	C	4	do	155	1¼	303	9,300	2,834	Do.
Black Diamond No. 2-A [3]	C	do	do	190	1¼	281	12,600	3,842	Illinois Powder Manufacturing Co., St. Louis, Mo.
Black Diamond No. 3-A [3]	C	do	do	156	1¼	294	11,160	3,402	Do.
Black Diamond No. 5	A	1*a*	do	180	1¼	288	6,020	1,835	Do.
Black Diamond No. 6, L. F [3]	C	4	do	158	1¼	306	9,630	2,935	Do.
Black Diamond No. 7 [3]	A	1*a*	do	183	1¼	214	10,730	3,270	Do.
Black Diamond No. 8 [3]	B	4	do	168	1¼	295	8,730	2,663	Do.
Cameron mine powder No. 1-A [4]	A	1*a*	do	156	1¼	227	10,950	3,339	Grasselli Powder Co., Cleveland, Ohio.
Cameron mine powder No. 2-A	A	do	do	[1] 224	1½	230	[5] 10,520	[5] 3,206	Do.
Cameron mine powder No. 2-A, L. F	A	do	do	215	1¼	233	10,950	3,338	Do.

[1] 1½ by 8 inch cartridge.
[2] Same as Coal Special 3-C.
[3] Same as corresponding brands of King.
[4] Same as Grasselli No. 1.
[5] 1½-inch diameter cartridge.

Permissible explosives tested to May 31, 1920—Continued.

Brand.	Class designation basis, volume of poisonous gases.	Class designation basis, characteristic ingredient.	When used with detonators, preferably electric detonators, of not less efficiency than—	Weight of 1¼ by 8 inch cartridge.	Smallest permissible diameter.	Unit deflective charge.	Rate of detonation in 1¼-inch diameter cartridges.		Manufacturer.
1	2	3	4	5	6	7	8		9
				Grams.	*Inches.*	*Grams.*	*Feet per second.*	*Meters per second.*	
Cameron mine powder No. 3-A [6]	C	4	No. 6	192	1¼	296	10,930	3,333	Grasselli Powder Co., Cleveland, Ohio.
Cameron mine powder No. 5-A	C	do	do	226	1⅛	299	8,900	2,712	Do.
Carbonite No. 1	C	do	do	226	1¼	280	100,950	3,338	E. I. du Pont de Nemours & Co., Wilmington, Del.
Carbonite No. 2	C	do	do	170	1¼	302	11,380	3,470	Do.
Carbonite No. 2, L. F	C	do	do	180	⅞	305	7,830	2,387	Do.
Carbonite No. 3	C	do	do	174	1¼	325	8,710	2,656	Do.
Carbonite No. 4	C	do	do	200	1¼	327	7,670	2,339	Do.
Carbonite No. 5	C	do	do	175	⅞	304	10,140	3,092	Do.
Carbonite No. 6	C	do	do	175	⅞	345	7,490	2,285	Do.
Coalite A, L. F	A	1*a*	do	164	⅞	204	11,590	3,534	Atlas Powder Co., Wilmington, Del., and the Giant Powder Co. (Con.), Giant, Calif.
Coalite B, L. F	A	do	do	147	⅞	205	11,390	3,474	Do.
Coalite C, L. F	A	do	do	166	⅞	215	12,190	3,716	Do.
Coalite D, L. F	A	do	do	154	⅞	214	12,070	3,680	Do.
Coalite E, L. F	A	do	do	168	⅞	237	6,220	1,896	Do.
Coalite H, L. F	A	do	do	184	1	260	6,350	1,936	Do.
Coalite X	A	do	do	156	1¼	226	9,000	2,745	Do.
Coalite Y	B	do	do	164	⅞	235	10,300	3,141	Do.
Coalite No. 1	C	4	do	232	1¼	296	7,930	2,418	Do.
Coalite No. 2-D	B	do	do	233	1¼	310	8,430	2,571	Do.
Coalite No. 2-D, L	C	do	do	146	1⅛	271	7,340	2,237	Do.
Coalite No. 2-M, L. F	C	do	do	157	1¼	301	9,220	2,811	Do.
Coalite No. 3-XC	B	1*a*	do	164	1¼	250	8,320	2,536	Atlas Powder Co., Wilmington, Del.
Coalite No. 3-YC	B	do	do	162	⅞	250	9,670	2,949	Atlas Powder Co., Wilmington, Del., and the Giant Powder Co. (Con.), Giant, Calif.
Coal special 1-A	C	4	do	148	1¼	276	9,370	2,857	Aetna Explosives Co. (Inc.), New York, N. Y.
Coal special 1, L. F	C	do	do	150	1¼	277	8,280	2,524	Do.
Coal special 2-W	C	do	do	180	1¼	277	11,590	3,534	Do.
Coal special 3-C [7]	C	do	do	192	1¼	288	9,760	2,977	Do.
Collier A	A	1*a*	do	160	⅞	215	11,280	3,440	Do.

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Collier B	B	do	do	156	⅞	207	10,970	3,345	Do.
Collier KN	A	do	do	175	1⅛	222	11,610	3,539	Do.
Collier Y	A	do	do	172	1¼	229	9,740	2,970	Do.
Collier X, I. F. 1	B	do	do	164	⅞	237	8,140	2,483	Do.
Collier X, I. F. 2	A	do	do	165	⅞	228	9,950	3,035	Do.
Collier 5	A	do	do	178	1¼	240	8,280	2,524	Do.
Collier 5, special	A	do	do	180	1⅛	236	8,330	2,541	Do.
Collier 6	A	do	do	169	⅞	214	11,220	3,422	Do.
Collier 11	A	do	do	165	⅞	217	11,680	3,561	Do.
Collier 11, L. F.	B	do	do	180	1¼	226	10,850	3,307	Do.
Cronite No. 1	A	do	do	149	1¼	233	10,490	3,198	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Cronite No. 5	B	do	No. 7	165	1¼	249	8,090	2,466	Do.
Duobel	B	do	No. 6	146	⅞	213	10,960	3,341	E. I. du Pont de Nemours & Co., Wilmington, Del.
Du Pont Permissible No. 1	B	do	do	175	⅞	278	9,610	2,930	Do.
Eureka No. 2	B	2	do	190	1¼	311	10,720	3,269	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Franklinite 1	C	4	do	192	1¼	288	9,760	2,977	Aetna Explosives Co. (Inc.), New York, N. Y.
Franklinite 4	B	do	do	198	1¼	344	7,010	2,138	Do.
Fuel-ite No. 3[8]	B	1a	do	179	1¼	215	8,590	2,620	Grasselli Powder Co., Cleveland, Ohio.
Fuel-ite No. 3, L. F[8]	B	do	do	172	1¼	229	10,810	3,296	Do.
General A	C	4	do	204	1⅛	274	13,500	4,116	General Explosives Co., Joplin, Mo.
General B	C	do	do	187	1¼	299	10,640	3,244	Do.
General C	B	do	do	186	1⅛	304	10,460	3,190	Do.
General 1	A	1a	do	168	⅞	208	10,650	3,247	Do.
General 2	A	do	do	152	⅞	217	11,510	3,508	Do.
General 3–X	A	do	do	203	1⅛	230	8,950	2,730	Do.
General 4	A	do	do	170	⅞	227	10,920	3,330	Do.
General 5[9]	A	do	do	194	1⅛	220	10,510	3,204	Do.
General 6–X[10]	A	do	do	194	1⅛	220	10,510	3,204	Do.
General Y	B	do	do	154	⅞	221	12,050	3,674	Do.
Giant coal mine powder No. 5	B	do	do	157	1¼	228	10,230	3,118	Giant Powder Co. (Con.), Giant, Calif.
Grasselli A[11]	B	4	do	183	1¼	296	11,290	3,443	Grasselli Powder Co., Cleveland, Ohio.
Grasselli A A[12]	C	do	do	156	1¼	319	10,670	3,252	Do.
Grasselli B[11]	C	do	do	168	1¼	340	9,540	2,908	Do.
Grasselli C[13]	C	do	do	192	1¼	296	10,930	3,333	Do.
Grasselli No. 1[14]	A	1a	do	156	1¼	227	10,950	3,339	Do.
Grasselli No. 3[15]	B	do	do	179	1¼	215	8,590	2,620	Do.
Grasselli No. 3, L. F.[15]	B	do	do	172	1¼	229	10,810	3,296	Do.
Grasselli No. 5[16]	A	do	do	161	1¼	241	8,720	2,658	Do.
Grasselli No. 6[17]	B	do	do	169	1¼	224	8,090	2,467	Do.
Guardian No. 2	A	4	do	202	1¼	245	8,980	2,738	Hercules Powder Co., Wilmington, Del.
Guardian No. 2–X	A	do	do	204	1¼	245	7,990	2,437	Do.
Guardian No. 3	B	do	do	186	1¼	272	7,660	2,336	Do.
Guardian No. 3–X	A	do	do	183	1¼	252	8,470	2,582	Do.
Hygrade coal powder No. 2	B	do	do	232	1¼	329	8,450	2,576	Hygrade Powder Co., Philadelphia, Pa.
Kanite A	A	1b	No. 8	[18] 319	1¾	255	[19] 10,730	[19] 3,270	W. H. Blumenstein Chemical Works, Pottsville, Pa.
King No. 2–A[20]	C	4	No. 6	190	1¼	281	12,600	3,842	The King Powder Co., Cincinnati, Ohio.

[6] Same as Grasselli C.
[7] Same as Aetna Coal Powder B+.
[8] Same as corresponding brands of Grasselli.
[9] Same as General 6–X.
[10] Same as General 5.
[11] Same as corresponding brands of Mine-ites.
[12] Same as Mine-ite A–2.
[13] Same as Cameron mine powder No. 3–A.
[14] Same as Cameron mine powder No. 1–A.
[15] Same as corresponding brands of Fuel-ites.
[16] Same as Mine-ite 5–D.
[17] Same as Mine-ite 6–D.
[18] 1¾ by 8 inch cartridge.
[19] 1¼-inch diameter cartridge.
[20] Same as corresponding brands of Black Diamond.

Permissible explosives tested to May 31, 1920—Continued.

Brand.	Class designation basis, volume of poisonous gases.	Class designation basis, characteristic ingredient.	When used with detonators, preferably electric detonators, of not less efficiency than—	Weight of 1¼ by 8 inch cartridge.	Smallest permissible diameter.	Unit deflective charge.	Rate of detonation in 1¼-inch diameter cartridges.		Manufacturer.
1	2	3	4	5	6	7	8		9
				Grams.	*Inches.*	*Grams.*	*Feet per second.*	*Meters per second.*	
King No. 3-A [20]	C	4	No. 6	156	1¼	294	11,160	3,402	The King Powder Co., Cincinnati, Ohio.
King No. 5 [20]	A	1a	do	180	1¼	288	6,020	1,835	Do.
King No. 6, L. F. [20]	C	4	do	158	1¼	306	9,630	2,935	Do.
King No. 7 [20]	A	1a	do	183	1¼	214	10,730	3,270	Do.
King No. 8 [20]	B	4	do	168	1¼	295	8,730	2,663	Do.
Little Red No. 2	B	do	do	185	⅞	321	9,300	2,836	The Equitable Powder Manufacturing Co., and the Egyptian Powder Co., East Alton, Ill.
Little Red No. 3	C	do	do	163	⅞	325	7,940	2,421	Do.
Little Red No. 4	B	do	do	193	⅞	349	8,100	2,469	Do.
Little Red No. 5, L. F	B	do	do	177	⅞	300	11,110	3,387	Do.
Little Red No. 6, L. F	B	do	do	168	⅞	333	7,650	2,331	Do.
Lomite No. 1	B	2	do	176	1¼	300	13,940	4,250	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Lowinite No. 2-B	A	1a	do	148	¼	258	9,740	2,971	Lowinite Explosives Manufacturing Co., Pittsburgh, Pa.
Mine-ite A [8]	B	4	do	183	1¼	296	11,290	3,443	Grasselli Powder Co., Cleveland, Ohio.
Mine-ite A-2 [21]	C	do	do	156	1¼	319	10,670	3,252	Do.
Mine-ite B [8]	C	do	do	168	1¼	340	9,540	2,908	Do.
Mine-ite No. 5-D [22]	A	1a	do	161	1¼	241	8,720	2,658	Do.
Mine-ite No. 6-D [23]	B	do	do	169	1¼	224	8,090	2,467	Do.
Miners Friend No. 1	B	do	do	167	⅞	223	11,580	3,529	Atlas Powder Co., Wilmington, Del.
Miners Friend No. 2	B	do	do	166	⅞	242	10,330	3,149	Do.
Miners Friend No. 3	B	do	do	167	⅞	242	8,030	2,449	Do.
Miners Friend No. 4	B	do	do	166	⅞	249	9,980	3,044	Do.
Miners Friend No. 5	B	do	do	166	⅞	250	8,570	2,614	Do.
Miners Friend No. 6	B	do	do	166	⅞	224	10,900	3,324	Do.
Miners Friend No. 7	A	do	do	176	⅞	253	8,950	2,729	Do.
Miners Friend No. 8, L. F	A	4	do	193	1¼	421	4,650	1,417	Do.
Monobel Y	B	1a	do	168	⅞	232	9,300	2,835	E. I. du Pont de Nemours & Co., Wilmington, Del.
Monobel No. 1	B	do	do	179	1¼	216	11,700	3,568	Do.
Monobel No. 2	B	do	do	178	⅞	239	9,870	3,009	Do.

Monobel No. 3	B	do	do	174	⅞	243	7,260	2,212	Do.
Monobel No. 4	B	do	do	174	⅞	248	8,980	2,738	Do.
Monobel No. 5	B	do	do	179	1	267	6,760	2,061	Do.
Monobel No. 6	B	do	do	175	⅞	218	10,380	3,165	Do.
Monobel No. 7	B	do	do	180	⅞	211	10,050	3,065	Do.
Nitro low-flame No. 1	C	4	do	234	1¼	303	13,380	4,079	Nitro Powder Co., Kingston, N. Y.
Nitro low-flame No. 2	C	do	do	226	1¼	298	14,560	4,439	Do.
Red H No. 1	B	1a	do	167	1¼	216	11,700	3,568	Hercules Powder Co., Wilmington, Del.
Red H No. 2	B	do	do	160	⅞	239	9,870	3,009	Do.
Red H No. 3	B	do	do	173	⅞	243	7,260	2,212	Do.
Red H No. 4	B	do	do	164	⅞	248	8,980	2,738	Do.
Red H No. 5	B	do	do	170	1	267	6,760	2,061	Do.
Red H No. 6	B	do	do	162	⅞	218	10,380	3,165	Do.
Red H No. 7	B	do	do	180	⅞	211	10,050	3,065	Do.
Red H No. 8	B	do	do	164	⅞	278	7,590	2,315	Do.
Red H No. 11	B	do	do	151	⅞	210	11,090	3,381	Do.
Red H No. 14	B	do	do	151	⅞	236	10,470	3,192	Do.
Trojan coal powder H	A	3	do	218	1¼	394	9,420	2,872	Pennsylvania Trojan Powder Co., Allentown, Pa.
Trojan coal powder I	A	do	do	218	1¼	410	9,620	2,934	Do.
Trojan coal powder J	A	do	do	229	1¼	360	10,590	3,230	Do.
Trojan coal powder K	B	do	do	181	1⅛	314	10,380	3,164	Do.
Trojan coal powder L	B	do	do	166	1⅛	275	10,560	3,221	Do.
Trojan granular coal powder No. 1	A	do	do	[24] 247	1⅞	265	[25] 7,920	[25] 2,416	Do.
Tunnelite AA	A	1a	do	176	1⅛	253	7,690	2,346	G. R. McAbee Powder & Oil Co., Pittsburgh, Pa.
Tunnelite B	B	do	do	167	1⅛	249	9,990	3,047	Do.
Tunnelite C	A	do	do	187	1⅛	255	10,060	3,068	Do.
Tunnelite No. 3	C	4	do	150	1⅛	291	10,110	3,083	Do.
Tunnelite No. 4	C	do	do	136	1⅛	309	10,620	3,238	Do.
Tunnelite No. 5	C	do	do	176	1¼	328	8,400	2,562	Do.
Tunnelite No. 6	C	do	do	172	1¼	305	9,670	2,947	Do.
Tunnelite No. 6, L. F	C	do	do	156	1¼	301	9,620	2,933	Do.
Tunnelite No. 7	C	4	do	164	1¼	311	8,720	2,659	Do.
Tunnelite No. 8	C	do	do	158	1¼	324	8,020	2,446	Do.
Tunnelite No. 8, L. F	C	do	do	176	1¼	322	8,720	2,658	Do.
Vigorite No. 1	C	do	do	204	1¼	259	10,950	3,338	Atlas Powder Co., Wilmington, Del., and the Giant Powder Co. (Con.), Giant, Calif.
Vigorite No. 2	C	do	do	168	⅞	298	10,920	3,330	Do.
Vigorite No. 3	B	do	do	160	⅞	320	8,140	2,483	Do.
Vigorite No. 4	B	do	do	200	⅞	341	7,480	2,281	Do.
Vigorite No. 5	C	do	do	165	⅞	304	10,830	3,303	Do.
Vigorite No. 6	C	do	do	166	⅞	345	7,490	2,285	Do.
Xpdite No. 1	C	do	do	211	1¼	259	10,950	3,338	Hercules Powder Co., Wilmington, Del.
Xpdite No. 2	C	do	do	168	1¼	302	11,380	3,470	Do.
Xpdite No. 3	C	do	do	162	1¼	325	8,710	2,656	Do.
Xpdite No. 4	C	do	do	190	1¼	327	7,670	2,339	Do.
Xpdite No. 5	C	do	do	166	⅞	304	10,140	3,092	Do.
Xpdite No. 6	C	do	do	165	⅞	345	7,490	2,285	Do.

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[21] Same as Grasselli AA.

[22] Same as Grasselli No. 5.

[23] Same as Grasselli No. 6.

[24] 1⅞ by 8 inch cartridge.

[25] 1⅞-inch diameter cartridge.

CLASSES OF PERMISSIBLE EXPLOSIVES.

In order that the user of explosives may be able the better to select an explosive to meet a specific requirement the Bureau of Mines now classifies permissible explosives in two ways, as follows: (1) On the basis of the volume of poisonous gases produced by 1½ pounds (680 grams) of the explosive, and (2) on the basis of the characteristic ingredient of each explosive.

VOLUME OF POISONOUS GASES.

Most permissible explosives when properly detonated in a drill hole in a coal mine produce poisonous gases, but they produce at the same time a much larger volume of nonpoisonous gases. In order that the poisonous gases may not under normal conditions become a menace to the lives or health of miners no explosive is now or can become permissible if it evolves upon detonation more than 158 liters (5½ cubic feet) of permanent poisonous gases, as determined by test in the Bichel pressure gage. Field tests of an explosive made under extreme conditions for the production of the greatest percentage of poisonous gases in the air show that in a narrow entry, with no ventilation at or near the face, a 1½-pound charge of an explosive, which gave 158 liters of poisonous gas in gage tests, produced 0.18 per cent of carbon monoxide (the only poisonous gas present) in the air when the sample was taken two minutes after the shot. Another sample of the air taken two minutes later contained 0.08 per cent of carbon monoxide. It is therefore evident that where ventilation is not active, as in a closed heading, miners or shot firers should not return to the face until at least five minutes after a shot. At all working faces that are difficult to ventilate explosives of class A or class B should be used, preferably those of class A.

The classification on the basis of the volume of poisonous gases produced by 1½ pounds (680 grams) of the explosive is as follows:

Class A, those explosives from which the volume of poisonous gases produced is not more than 53 liters.

Class B, those explosives from which the volume of poisonous gases is more than 53 liters but less than 106 liters, inclusives.

Class C, those explosives in which the volume of poisonous gases is more than 106 liters but less than 158 liters, inclusive.

CHARACTERISTIC INGREDIENTS.

Explosives are classified in accordance with their characteristic ingredient as follows:

Class 1, ammonium nitrate explosives.—To class 1 belong all the explosives in which the characteristic ingredient is ammonium nitrate.

This class is divided into two subclasses. Subclass A includes every ammonium nitrate explosive that contains a sensitizer that is in itself an explosive. Subclass B includes every ammonium nitrate explosive that contains a sensitizer that is not in itself an explosive. The ammonium nitrate explosives of subclass A consist principally of ammonium nitrate with small percentages of nitroglycerin, nitrocellulose, or nitrosubstitution compounds which are used as sensitizers. The ammonium nitrate explosives of subclass B consist principally of ammonium nitrate with small percentages of resinous matter or other nonexplosive substances used as sensitizers.

Ammonium nitrate explosives, when fresh and properly detonated, are well adapted for use in mines that are not unusually wet. They are not suitable for use in wet mines, for if the contents of a cartridge of ammonium nitrate explosive is exposed for only a few hours to the damp atmosphere the explosive may so deteriorate as to fail to detonate completely, because ammonium nitrate takes up moisture readily. The redipping of cartridges of ammonium nitrate explosives aids in protecting the contents against moisture, or moist air, and the cartridges should be so stored and handled as to preserve the efficacy of the paraffin-like coating. The explosives should be obtained in a fresh condition and purchased in such quantities as will permit their prompt use. Experience at the Pittsburgh experiment station of the bureau shows that ammonium nitrate explosives will usually detonate completely after storage for six months in a well-ventilated magazine.

Class 2, hydrated explosives.—To class 2 belong all explosives in which salts containing water of crystallization are the characteristic ingredients. The explosives of this class are somewhat similar in composition to the ordinary low-grade dynamites, except that one or more salts containing water of crystallization are added to reduce the flame temperature. They are easily detonated, and most of them can be used successfully in damp working places.

Class 3, organic nitrate explosives.—To class 3 belong all the explosives in which the characteristic ingredient is an organic nitrate other than nitroglycerin. The permissible explosives now listed under class 3 are nitrostarch explosives.

Class 4, nitroglycerin explosives.—To class 4 belong all the explosives in which the characteristic ingredient is nitroglycerin. These explosives contain free water or an excess of carbon, which is added to reduce the flame temperature. A few explosives of this class contain salts, or an unusually low percentage of nitroglycerin, that reduce the strength and shattering effect of the explosives on detonation. The nitroglycerin explosives have the advantages of detonating easily and of not being readily affected by moisture.

WEIGHT OF 1¼ BY 8 INCH CARTRIDGE.

The size in which cartridges of permissible explosives are usually sold is 1¼ by 8 inches, and from the weight of a cartridge of this size as given in the table the number of cartridges required to make the 680 grams (1½ pounds) maximum permissible quantity of explosive in a shot may be readily determined. To illustrate, the first explosive on the accompanying list (Aetna coal powder A), like all the other explosives on the list, is permissible only when fired in charges not exceeding 680 grams (1½ pounds). The maximum permissible weight per shot (680 grams), divided by the weight of one 1¼ by 8 inch cartridge (184 grams of Aetna coal powder A), gives the maximum permissible number of cartridges of this size that may be used, 3⅝ (or 3.69) cartridges.

SMALLEST PERMISSIBLE DIAMETER.

In order that the user may know readily the smallest diameter in which a given explosvie is permissible, this information is given in the table. Should a manufacturer desire that an explosive be approved as permissible in a smaller diameter than that in which it is now permissible, he should make application for the necessary tests.

UNIT DEFLECTIVE CHARGE AS DETERMINED BY THE BALLISTIC PENDULUM.

The figures in the seventh column of the table show the weight in grams of the quantity of explosive that is required to swing the pendulum mortar the same distance as one-half pound (227 grams) of the standard 40 per cent "straight" nitroglycerin dynamite of the Pittsburgh testing station of the Bureau of Mines. Many observers have expressed the opinion that the "coal-getting" strength of permissible explosives is represented better by the results of this test than by the results of any other single test yet devised. The reader should note that the results do not take into consideration whether the coal when shot down is fine or coarse.

In comparing the unit deflective charge of one explosive with that of another explosive a fine distinction should not be drawn, for it must be remembered that tolerance limits have been established for the results with the ballistic pendulum, as given on page 30, and these limits are designed to cover all reasonable variations of manufacture, sampling, and chemical and physical determinations made. This principle applies to all the items of the chemical analysis as well as to the items of the physical tests.

RATE OF DETONATION.

The table shows in feet per second and meters per second the relative velocity of detonation of each explosive. The adaptability of a permissible explosive to a particular coal-mining condition depends greatly on its rate of detonation. For certain work in which a shattering effect is desired, as in driving through or "brushing" rock, or in producing coal for coke making, the explosive reaction should be rapid, and for such work permissible explosives having a high rate of detonation should be selected. Similarly, for shooting down a soft, friable coal to produce lump or steam coal, a permissible explosive should be selected that detonates slowly and hence gives a more prolonged pressure. In medium hard coal an explosive having an intermediate rate of detonation may be expected to be most suitable.

Although these relations usually hold, they do not always, because coals differ in hardness and coal beds differ in the number and position of the joints, partings, and shale bands. Such facts have to be considered in selecting an explosive for mining coal.

An explosive having a very low rate of detonation is not always the best for mining a friable coal much fractured, because some of its energy may be lost by its gases escaping through the fractures. Under such conditions an explosive having an intermediate rate produces the most economical results.

STORAGE OF PERMISSIBLE EXPLOSIVES.

The bureau is now re-examining permissible explosives found in commercial shipments and in the field to determine how closely they conform to the samples upon which the permissibility tests were originally made. In order that this examination should be properly made, tolerances[1] were established by the bureau on July 1, 1915.

One of the provisions of these tolerances is "that where the Bureau of Mines finds a sample which does not come up to the tolerance limits, the bureau shall simply declare that particular lot of explosives not permissible, and a copy of the notification to the consumer or owner shall be furnished the manufacturer".

The usual causes of an explosive exceeding the tolerances for chemical analysis or physical tests are two: (1) It may not have been properly manufactured; (2) it may not have been properly stored. The manufacturer is responsible for 1 because the consumer has no control over the method of manufacture of the explosive, but the consumer or owner is responsible for 2 because the manufacturer has no control over the conditions of storage when the explosive has once passed from his ownership. When a given lot of explosive is declared nonpermissible both the owner and the manufacturer are notified. The bureau does not attempt to fix the responsibility as between owner and manufacturer.

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[1] Storm, C. G., The analysis of permissible explosives: Bull. 96, Bureau of Mines, 1916, pp. 80–81.

The manufacturer should exercise due care that the quality of the raw materials, and the weighing and incorporating of them is similar in all respects to that for the original sample of explosives submitted for tests; and that the explosive is fresh and in first-class condition when sold. The user should store explosives in well-ventilated magazines, at temperatures not exceeding 90° F. The boxes should be placed so that the cartridges lie horizontally, though the tops of the boxes may be up or down. The explosives purchased first should be used first, and hence older explosives should not be stored under or behind a fresh consignment. It is well to purchase explosives in such quantities that they can be used promptly.

TOLERANCES FOR PERMISSIBLE EXPLOSIVES.

The tolerances promulgated by the Bureau of Mines to provide for reasonable limits of variation in the results of analyses and tests of permissible explosives are given below. If these tolerances are exceeded by a given lot of any permissible explosive it is not permissible. The tolerances established, which were made effective July 1, 1915, and were first published in Bulletin 96, as previously stated, are as follows:

In order to define more exactly what is meant by the phrase "similar in all respects" in the definition of a permissible explosive, namely, "an explosive is called a permissible explosive when it is similar in all respects to the sample that passed certain tests by the United States Bureau of Mines, and when it is used in accordance with the conditions prescribed by this bureau," the following tolerances are recommended for field samples or manufacturers' samples of explosives, beyond which such lot of explosives can not vary and still be considered permissible for use in coal mines: *Provided*, That where the Bureau of Mines finds a sample which does not come up to the tolerance limits, the bureau shall simply declare that particular lot of explosives not permissible, and a copy of the notification to the consumer or owner shall be furnished the manufacturer, the notification to state that the explosive did not meet the tolerance requirements for moisture or ingredients, etc., as the case might be.

Chemical analysis.—Moisture, to be fixed by a sliding scale of from 1½ per cent at zero to 4 per cent at 10 per cent of moisture in original sample, this tolerance being on total percentage of moisture in the explosive.

Other ingredients (or their equivalents) in quantities not exceeding 60 per cent, according to curve shown in figure 2. For ingredients in quantities of 60 per cent or more, the tolerance shall be plus or minus 3 per cent: *Provided*, That the ingredients of a permissible explosive shall be considered to be those substances reported as found by the Bureau of Mines in the original sample of that explosive submitted for test as to its permissibility: *And provided further*, That an equivalent shall be considered to be a substance which would not materially alter the properties of the explosive and which would produce the same result as the original substance.

Products of combustion (determined by Bichel gage tests).—The volume of poisonous gases from 680 grams of the explosive, including its wrapper, must be less than 158 liters, except that in case the first test yields 158 liters or more of poisonous gases per 680 grams of the explosive, including its wrapper, the average result of three tests agreeing within 5 per cent of each other shall be taken, and no explosive shall remain permissible when this average for poisonous gases exceeds the above standard limits.

Physical tests.[1]

Rate of detonation (the average of three trials with Mettegang's recorder), plus or minus 15 per cent.

Unit deflective charge (the average of three trials with the ballistic pendulum), plus or minus 10 per cent.

Grams of wrapper per 100 grams of explosive, plus or minus 2.0 grams (average of four determinations): *Provided,* That the manufacturers shall submit samples of all different sizes of cartridges, to be considered as part of the original sample, the amount of wrapper to be determined for each size of sample: *And provided further,* That the tolerances as suggested shall be determined in comparison with the various diameters of samples as submitted with the original sample.

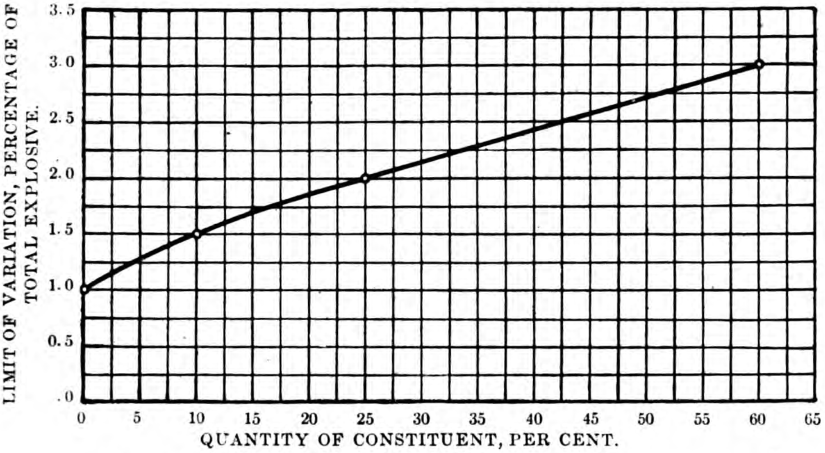

FIG. 2.—Curve of limit variation in composition of permissible explosives.

Apparent specific gravity of cartridge, by sand, plus or minus 7.5 per cent (average of four determinations): *Provided,* That actual density shall be determined on cartridges of the same diameter as the standard: *And provided further,* That manufacturers shall be required to submit samples of all sizes.

Gas and dust gallery No. 1.—No ignition must be obtained in each of one or more trials. Note: In the retesting of permissible explosives by tests 1, 3, and 4,[2] the charges of the explosives fired will be reduced 10 per cent in weight from the weights originally used in order to eliminate any liklihood of a failure being due to the natural variations in the gallery conditions.

Pendulum friction test.—Each explosive must pass a test of 10 trials under the same conditions as originally tested, except that the height of fall of the wood-fiber shoe will be reduced by 10 per cent in order to eliminate any liklihood of a failure being due to the natural variations in test conditions.

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[1] For method of making these tests, see Howell, S. P., and Tiffany, J. E., Methods for routine work in the explosives physical laboratory of the Bureau of Mines: Tech. Paper 186, Bureau of Mines, 1918, 63 pp.

[2] Work cited, p. 23.

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